1983

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Bulletin No. 755 September 1983

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Contents

Tables

Figures

Acknowledgments

The authors wish to acknowledge the contribution of Dr. John D. C. Baldwin, Associate Professor, Department of Agricultural Engineering, Agricultural Experiment Station, LSU Agricultural Center, Baton Rouge, for development of computer software which helped in the construction of the tables and figures. We also thank Mr. Mykal Sylva and Mr. John McLaughlin, Research Assistants, Department of Agricultural Engineering, LSU, for help with data compilation.

Climate at the Northeast Research Station

St. Joseph, Louisiana 1931-80

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The Northeast Research Station, previously known as the Northeast Louisiana Experiment Station, is located approximately 3 miles west of the Mississippi River near the town of St. Joseph, Louisiana, in Tensas Parish. Geographically, the surrounding region is part of the Coastal Plain physiographic province of continental North America. Subsurface material is composed of geologically recent Mississippi alluvial deposits with surface material being composed of mixed textural classes of flood plain origin. Natural vegetation is predominantly mixed species of bottomland hardwoods although much of the natural landscape has been converted to agricultural land-uses.

The Northeast Station was originally established in 1929 as a branch of the Louisiana Agricultural Experiment Station. Its primary goal is to develop and disseminate information concerning the production of agronomic crops, such as cotton, soybeans, corn, rice, wheat, and grain sorghum, and cattle in the northeastern region of Louisiana. As climatic information is integral to agricultural planning, climatic data collection was implemented in March 1930, shortly after establishment of the station. Initially, only temperature (daily maximum and minimum) and precipitation (24 hour) were recorded. Pan evaporation measurements began in August 1960 and continued until April 1963; measurement was reinstituted in April 1970 and continues to the present. Finally, soil temperatures were recorded beginning in 1966 although depth of measurement was lowered from 2 inches to 4 inches in 1976 (Table 5).

Data in this publication represent 50 years of continuous daily recordings. In some cases, when data were missing, data at nearby stations

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were used to reconstruct and complete the climatic record at the station. It should be made clear that the data reflect climate at the Northeast Station only, although within certain limits the data reflect general patterns of climate for the northeastern region of Louisiana.

Average Climate

Average climatic characteristics at the Northeast Research Station are broadly classified as humid and subtropical. This designation references both its latitudinal location and the fact that annual precipitation exceeds annual evaporative demand. The humid, subtropical classification can be applied to much of the southeastern portion of the United States and, thus, climatic patterns observed at the location typify climatic conditions for this general region.

Data illustrating long-term (50-year) average temperature and precipitation conditions at the station are shown in Table 1. Also included are data for other stations, located east and west, at similar latitudes. Holding latitude constant suggests that differences between stations stem from factors other than the amount of potential solar radiation delivery and daylight. An examination of Table 1 shows that the climate at the Northeast Station closely resembles the climate at stations to the east but is quite different from the climate at stations to the west. The southeastern stations, including the Northeast Station, show a high degree of similarity in annual temperature, temperature regime, annual precipitation, and precipitation regime. However, southwestern stations, despite higher elevations, show higher summer temperatures, lower winter temperatures (except Tucson, Arizona) and significantly reduced amounts of annual precipitation.

Differences observed between southeastern and southwestern stations are largely related to three key factors. First, although potential solar radiation levels and daylight are nearly the same at each station, it is probable that southeastern stations receive lower inputs of actual solar radiation at the surface due to greater amounts of cloud cover and atmospheric turbidity. Second, topography and greater distance from a readily available moisture source, such as the Gulf of Mexico, interact to give southwestern stations reduced amounts of precipitation. Finally, because of a relative shortage of soil moisture caused by reduced amounts of precipitation, much of the incoming solar radiation is converted directly into sensible heat at the southwestern stations while at the southeastern stations much of the incoming solar radiation is used to evaporate water and, thus, is not available for heating. Southwestern stations at similar latitudes will tend to record higher temperatures under similar solar radiation loads due to differences in the partitioning of solar radiation between sensible heat and evaporation.

TABLE I. COMPARATIVE CLIMATIC TRANSECT OF STATIONS AT 32 N. LATITUDE

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1. TUCSON, ARIZ. (32°07'N, 110°56'W; 2582 ft.)													
TEMPERATURE (°F)	50.9	53.5	57.6	65.5	73.6	82.1	86.3	83.8	80.1	70.1	58.5	52.0	67.8°
PRECIPITATION (in)	0.77	0.70	0.64	0.35	0.14	0.20	2.38	2.34	1.37	0.66	0.56	0.94	11.05"
2. EL PASO, TEX. (31°48'N, 106°24'W; 3921 ft.)													
TEMPERATURE (°F)	43.6	48.4	54.6	63.9	73.2	80.3	82.3	80.5	74.2	64.0	51.6	44.5	63.3°
PRECIPITATION (in)	0.39	0.42	0.39	0.24	0.32	0.60	1.53	1.12	1.16	0.78	0.32	0.50	7.77"
3. ABILENE, TEX. (32°26'N, 99°41'W; 1759 ft.)													
TEMPERATURE (°F)	43.7	47.9	54.5	65.2	72.4	80.3	83.5	83.6	76.1	66.1	54.1	46.4	64.5°
PRECIPITATION (in)	1.02	0.97	0.98	2.47	3.86	2.82	2.34	2.05	2.26	2.60	1.20	1.04	23.59"
4. NE LOUISIANA EXPERIMENT STATION (31° 55'N, 91°14'W; 79 ft.)													
TEMPERATURE (°F)	47.8	50.8	57.5	65.6	72.8	79.2	81.6	81.0	76.1	65.9	56.0	49.9	65.4°
PRECIPITATION (in)	5.68	5.04	6.13	5.34	5.04	3.37	4.48	3.27	2.72	2.61	4.32	5.65	53.64"
5. MERIDIAN, MISS. (32°20'N, 88°45'W; 295 ft.)													
TEMPERATURE (°F)	46.9	49.8	56.1	65.4	72.4	79.2	81.2	80.7	75.3	64.8	54.2	47.9	64.5°
PRECIPITATION (in)	4.53	4.86	6.21	5.10	3.84	3.68	5.12	3.89	3.29	2.18	3.51	5.57	51.58"
6. MONTGOMERY, ALA. (32°42'N, 88° 14'W; 194 ft.)													
TEMPERATURE (°F)	47.5	50.6	56.5	65.3	72.4	78.9	81.0	80.7	76.0	65.8	55.0	48.5	64.8°
PRECIPITATION (in)	4.02	4.30	6.02	4.45	3.47	4.03	5.09	3.47	4.41	2.24	3.43	4.93	49.86"

The long-term (50-year) data on temperature and precipitation at the Northeast Station, by month, are summarized in Tables 2 and 3. The average climate shows a rather moderate temperature curve with the lowest average monthly value occurring in January (47.8°F) and the highest average monthly temperature occurring in July (81.6°F). The moderate nature of the annual temperature curve is further illustrated by the fact that only 7.2°F of average temperature difference exists during the 5 warmest months (May-September); likewise, the 5 coldest months (November-March) differ by only 9.7°F. In a sense the climate of the Northeast Station

SUMMARY OF MONTHLY TEMPERATURE AND PRECIPITATION (1931-1980)

TABLE 2. MONTHLY TEMPERATURE (°F)

MONTH	AVERAGE	AVERAGE DAILY MIN.	AVERAGE DAILY MAX.	EXTREME DAILY MAX.	YEAR	EXTREME DAILY MIN.	YEAR
JAN	47.8	37.4	58.2	81	1935/1950	-8	1940
FEB	50.8	39.6	61.2	83	1940/1957	2	1951
MAR	57.5	46.0	68.8	89	1946	18	1980
APR	65.6	54.2	76.8	92	1943	29	1936
MAY	72.8	61.8	83.4	97	1951	40	1931
JUN	79.2	68.6	89.8	103	1936	48	1931
JUL	81.6	71.2	91.8	102	1960	52	1967
AUG	81.0	70.6	91.6	102	1935/43/51	52	1931
SEP	76.1	65.0	87.6	101	1951/80	35	1967
OCT	65.9	52.4	79.2	94	1954/1977	24	1952
NOV	56.0	43.4	68.4	87	1936/46	18	1937/38/51
DEC	49.9	39.0	60.8	83	1951	8	1962

TABLE 3. MONTHLY PRECIPITATION (IN.)

MONTH	AVERAGE	MINIMUM	YEAR	MAXIMUM	YEAR	MAXIMUM 24 HR	YEAR
JAN	5.68	1.26	1969	17.5	1979	6.64	1974
FEB	5.04	0.81	1943	11.13	1966	6.52	1946
MAR	6.13	1.13	1955	14.52	1976	6.73	1977
APR	5.34	0.81	1972	21.80	1940	9.85	1940
MAY	5.04	0.44	1963	15.29	1953	6.60	1953
JUN	3.37	0.09	1952	11.50	1945	5.49	1959
JUL	4.48	0.62	1962	16.04	1940	4.67	1931
AUG	3.27	0.44	1980	11.11	1970	4.64	1942
SEP	2.72	0.22	1931	7.94	1971	4.43	1950
OCT	2.61	0.00	1952	10.44	1970	5.93	1975
NOV	4.32	0.06	1949	14.10	1948	9.70	1964
DEC	5.65	0.88	1980	14.72	1932	4.93	1973

is composed of 5 months of "summer-like" weather and 5 months of "winter-like" weather. The transition between the two periods occurs generally in April and October during which average monthly temperatures increase by 15.2°F and fall by 16.0°F, respectively.

The average daily minimum and maximum temperatures by months are shown in Table 2. Interestingly, the data show that the typical range of daily temperatures is about 20°F in all months except October and November when the typical diurnal range is about 25°F. During the months of October and November there is a tendency for northeast Louisiana to be dominated by drier air masses which are conducive to slightly more extreme thermal conditions since they lack the buffering effects of humid air masses.

Information on the extremes of daily temperatures experienced at the Northeast Station is also shown in Table 2, categorized by month, for the 50-year record. Basically, the data show that below-freezing temperatures are possible from October through April although they are usually experienced from November through February only. The mildness of the thermal regime at the Northeast Station is attested to by the fact that all months of the year commonly experience daily maximum temperatures of more than 70°F. The climatic record shows that at least 1 day in 5 during all months will experience temperature at least this high.

Precipitation characteristics at the Northeast Station are summarized in Table 3. Annual precipitation averaged 53.64 inches during the course of the climatic record. While this amount exceeds evaporative demand (about 40 inches per year) it is not distributed evenly throughout the year. The annual precipitation regime at the Northeast Station is roughly inverse to the regime of temperature in that the largest monthly precipitation amounts are recorded in the months with the lowest temperatures and, thus, evaporative demand is relatively low. Much smaller amounts of precipitation are received during the high evaporative periods of summer and autumn. In fact, of the total annual precipitation only 38 percent is received during this period. During the 7-month growing season (April-October) an average of 26.8 inches of precipitation occurs. Thus, in an average year about 50 percent of average annual precipitation is received during months that are outside the active growing season for most crops. The fact that much of the annual precipitation does not occur during the time of maximum demand, i.e., during the growing season of the most important agronomic crops in the region, has significant implications for the management of land and water resources in the area.

Factors Controlling Climate

The annual regimes of temperature and precipitation at the Northeast Station are largely the function of locational factors relative to regional and global atmospheric dynamics. The latitudinal location assures relatively high levels of solar radiation year round. Potential solar radiation at the top of the atmosphere ranges between 1001 langleys per day in June to 486 langleys per day in December (Figure 1). The June value is 99 percent of the amount received at a location at 40°N (Columbus, Ohio), while December's value is some 44 percent greater than at 40°N. Thus, winter temperatures experienced at the Northeast Station are not nearly as severe as those experienced at locations further to the north, while summer temperatures are more nearly similar. Likewise, day-length changes shown in Figure 2 are also moderate with maximum length of day (14 hours 12

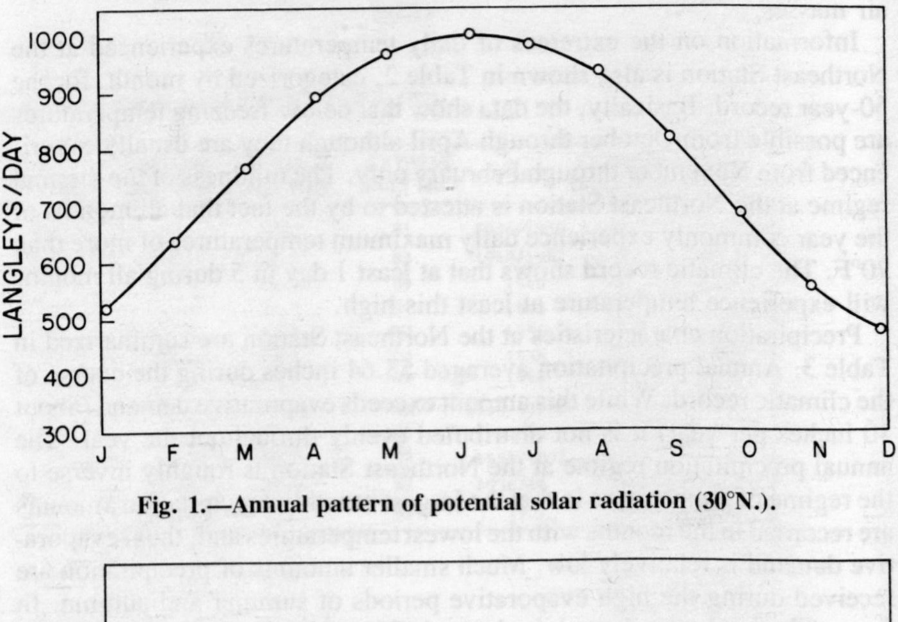


Fig. 1.—Annual pattern of potential solar radiation (30°N.).

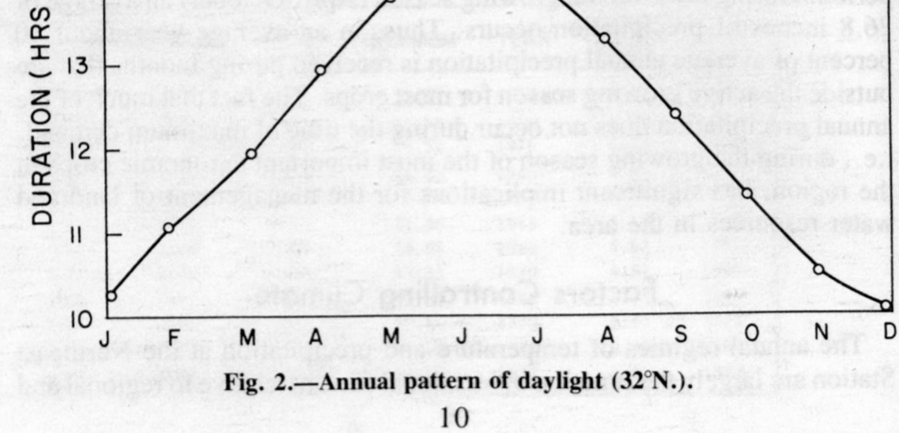


Fig. 2.—Annual pattern of daylight (32°N.).

minutes) occurring at the summer solstice and the minimum length of day (10 hours 6 minutes) occurring at the winter solstice.

Another important locational factor is the close proximity of the Northeast Station to the Gulf of Mexico. The Gulf serves as a continual source of warm, moist, tropical air masses which tend to dominate weather conditions year round. Tropical air masses are especially important during the summer and autumn. This type air mass, always warm with high humidity, is capable of giving up relatively large amounts of precipitation when subjected to free or forced convection. Since northeast Louisiana possesses little topographic relief, convection is accomplished through thermal heating (summer) and frontal convergence (winter). While very high amounts of precipitation are received during winter and spring months, development of high pressure over the Gulf and the Southeast during late summer and early autumn contributes to suppression of rainfall amounts below those received during the cooler part of the year.

A final locational factor important in controlling the climate at the Northeast Station is its geographic location relative to general circulation patterns of the atmosphere. Northeast Louisiana's latitude places it at the southern margin of the midlatitudes. This means it is transitional in climatic characteristics between a truly midlatitude climate, characterized by large seasonal climatic changes, and a truly tropical climate, characterized by little or no seasonal variability. In general, then, the climate of northeast Louisiana possesses attributes of each of these distinct climatic zones, being, for the most part, tropical-like during the summer and midlatitude-like during the winter.

The distinct seasonal nature of the northeast Louisiana climate is caused by shifts in climatic zones brought about by seasonal changes in solar radiation delivery. During the summer when solar radiation levels are high in the Northern Hemisphere, tropical air is brought well to the north of its winter location. Likewise, during the winter, colder continental air is brought well south of its more northerly summer location. The incursion of cold continental air into northeastern Louisiana is brought about by the development of midlatitude frontal systems which form at the boundary of tropical and continental air masses. The boundary also forms the principal storm track for midlatitude frontal disturbances. Thus, as the airmasses shift north and south so does the location of storm activity. These storm tracks tend to be located away from northeastern Louisiana during the summer and are usually close by during the winter. The autumn and spring months are transitional periods between extremes.

The weather, and ultimately the climate, at the Northeast Station is closely related to the configuration of the atmosphere which, in turn, controls the movement of air masses and their resultant weather conditions. To simplify this rather complex concept, Muller (1977) has developed a classification of weather types for Louisiana. This classification system essentially places all possible weather situations into eight distinct types. The eight weather types are illustrated in Figure 3 and briefly described below:

PACIFIC HIGH (PH): Circulation around a surface low to the north brings mild and relatively dry air from the west following the passage of a cold front through Louisiana.

CONTINENTAL HIGH (CH): The center of the high pressure system is usually east of the Rocky Mountains with a northerly flow across Louisiana. This type of weather is restricted to fair and cool to cold weather associated with the high pressure system.

FRONTAL OVERRUNNING (FOR): This type occurs when the polar front is more or less stationary along the Gulf Coast or over the northern Gulf. The associated weather includes brisk northerly to northeasterly winds, relatively low temperatures, low stratus clouds, and intermittent to steady precipitation.

COASTAL RETURN (CR): When the axis of the high pressure system drifts east of Louisiana, surface winds veer from the northeast to east to southeast. This weather type is usually associated with fair and cool weather in winter and spring, and fair but warm and muggy weather in summer and early autumn.

GULF RETURN (GR): As the high pressure ridge drifts even farther to the east, a strong southerly return flow of warm, moist maritime tropical air from the Caribbean and the Gulf sweeps over Louisiana. During winter and spring this weather type brings spells of sultry weather with fog in the mornings and billowing cumulus clouds in the afternoon, but with only a few brief showers. In the summer the weather is hot, humid, with little air movement and only scattered showers.

FRONTAL GULF RETURN (FGR): When the return flow of maritime tropical air is affected by convergence and lifting along an approaching cold front, showers, thunderstorms, squall lines, and occasional severe weather break out. This weather type includes situations in which the cold front from the west or north is within a zone extending about 300 miles from the baseline station.

GULF TROPICAL DISTURBANCES (GTD): During the summer and autumn, Louisiana is occasionally influenced by tropical storms which usually drift from east to west across the Gulf.

GULF HIGH (GH): During summer, especially, there are periods when the western extension of the Bermuda High is displaced southward over the Gulf of Mexico, and the weak local circulation is from the southwest. Usually, this flow consists of maritime tropical air but occasionally somewhat drier continental tropical air from western Texas or northern Mexico reaches Louisiana.

The weather types depicted in Figure 3 and discussed above provide a method through which local weather and climate can be summarized. Monthly and seasonal differences in climatic characteristics are related to

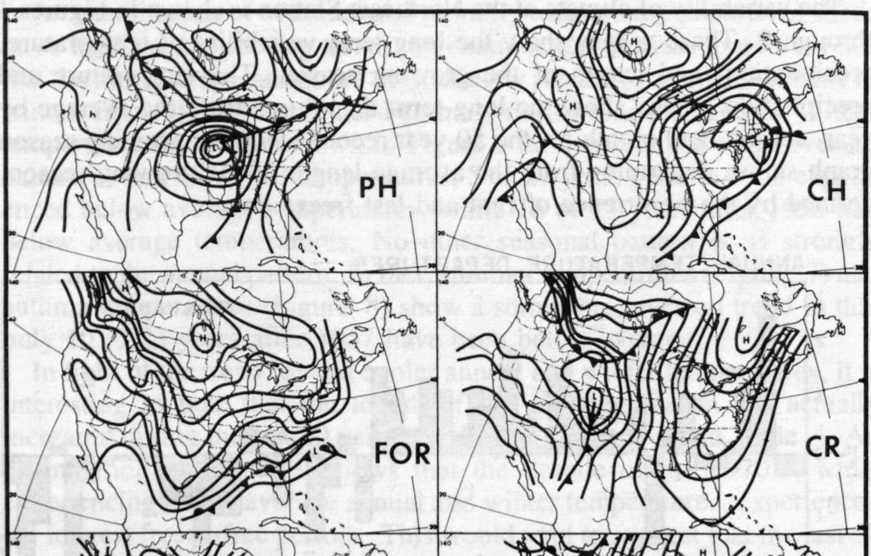
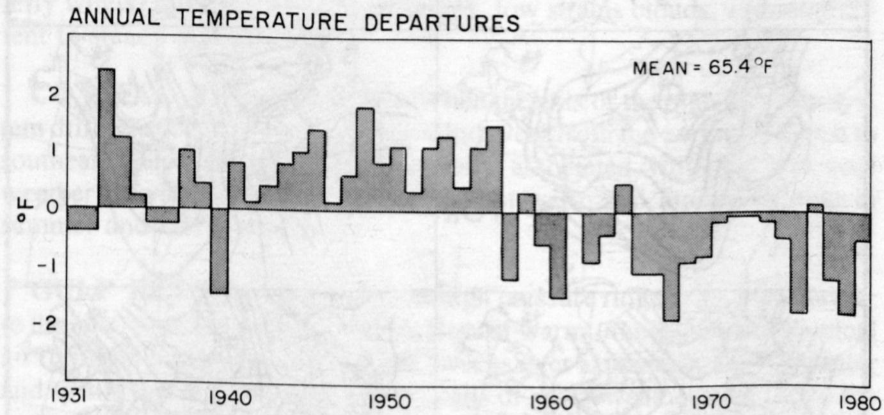


Fig. 3.—Synoptic weather types (PH = Pacific High; CH = Continental High; FOR = Frontal Overrunning, CR = Coastal Return; GR = Gulf Return; FGR = Frontal Gulf Return; GH = Gulf High; GTD = Gulf Tropical Disturbances).

the relative frequency with which the weather types occur. For example, a wet month or season would tend to have a disproportionate number of Frontal Overrunning and/or Frontal Gulf Return occurrences. In contrast, a cold and dry month would most likely record more Continental High weather.

Climatic Variability

The variability of climate at the Northeast Station is shown in Figures 4 through 9. These graphs show the long-term variability of temperature, precipitation, and length of the growing season. The temperature and precipitation graphs show the long-term departures from the average by year, season, and month for the 50-year record while the growing season graph shows departures from the average length of the growing season, defined by the occurrence of first and last freeze date.



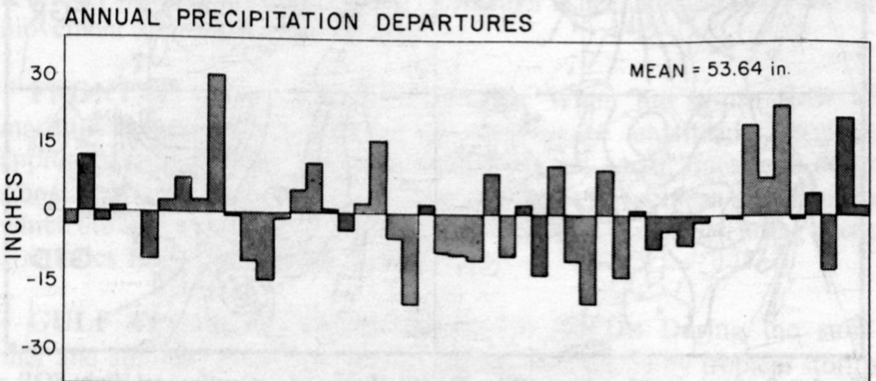


Fig. 4.—Long-term patterns of annual temperature and precipitation.

Departures of annual temperatures from the long-term average are shown in Figure 4. It can be seen that a decrease in annual temperatures occurred after 1957; before this date only 5 of 27 years (18 percent) recorded annual temperatures that were below the long-term average, while after that year 20 of 23 years (87 percent) recorded below average annual temperatures. This cooling shift is similar in timing and extent to others reported for the Southeast in the climatological and meteorological literature.

An examination of seasonal and monthly temperature departures sheds more light on this cooling trend. An examination of these graphs reveals that declining temperatures are most directly related to a general decline in winter temperatures (December-February) during the past 50 years. Winter temperature departures shown in Figure 5 have nearly the same over-all pattern as that of annual temperatures; 5 of 27 years prior to 1958 experienced below average temperatures, while 16 of 23 years after 1958 had below average temperatures. No other seasonal pattern is as strongly related to the annual pattern. In fact, summer temperatures (Figure 7) and autumn temperatures (Figure 8) show a somewhat reversed trend in that only 10 of 23 years after 1957 have been below average.

In light of the trend toward cooler annual and winter temperatures, it is interesting to note that the length of the growing season has actually increased during the last 50 years, as shown in Figure 9 and Table 4. An examination of Figure 9 shows that the decade of the 1970's, while experiencing below average annual and winter temperatures, experienced the longest freeze-free periods. This would tend to suggest that the last 50 years there has been a trend toward more severe but shorter winter thermal conditions at the Northeast Station.

Precipitation departures from the long-term average for the 50-year record are also depicted in Figures 4 through 8. Annual departures from the long-term average of 53.64 inches are shown in Figure 4. The pattern of annual departures does not show as spectacular a trend as that shown by annual temperature departures. It does, however, show somewhat of a "U-shaped" pattern; this is more clearly seen when decade averages of precipitation are examined. These averages are 57.6 inches, 53.9 inches, 47.3 inches, 49.4 inches and 59.7 inches for each of the five decades, respectively. It is clear that the decades of the 1930's and 1970's were wetter than the decades of the 1950's and 1960's. The decade of the 1940's experienced rainfall that was very close to the long-term average.

Seasonal and monthly departures from average precipitation are also shown in Fitures 5 through 8. An examination of the seasonal plots once again reaffirms the uneven distribution of precipitation throughout the year. Of the total amount of annual precipitation, 31 percent occurs in winter, 31 percent occurs during spring, 21 percent occurs during summer, and only 18 percent occurs during autumn. In terms of year-to-year varia-

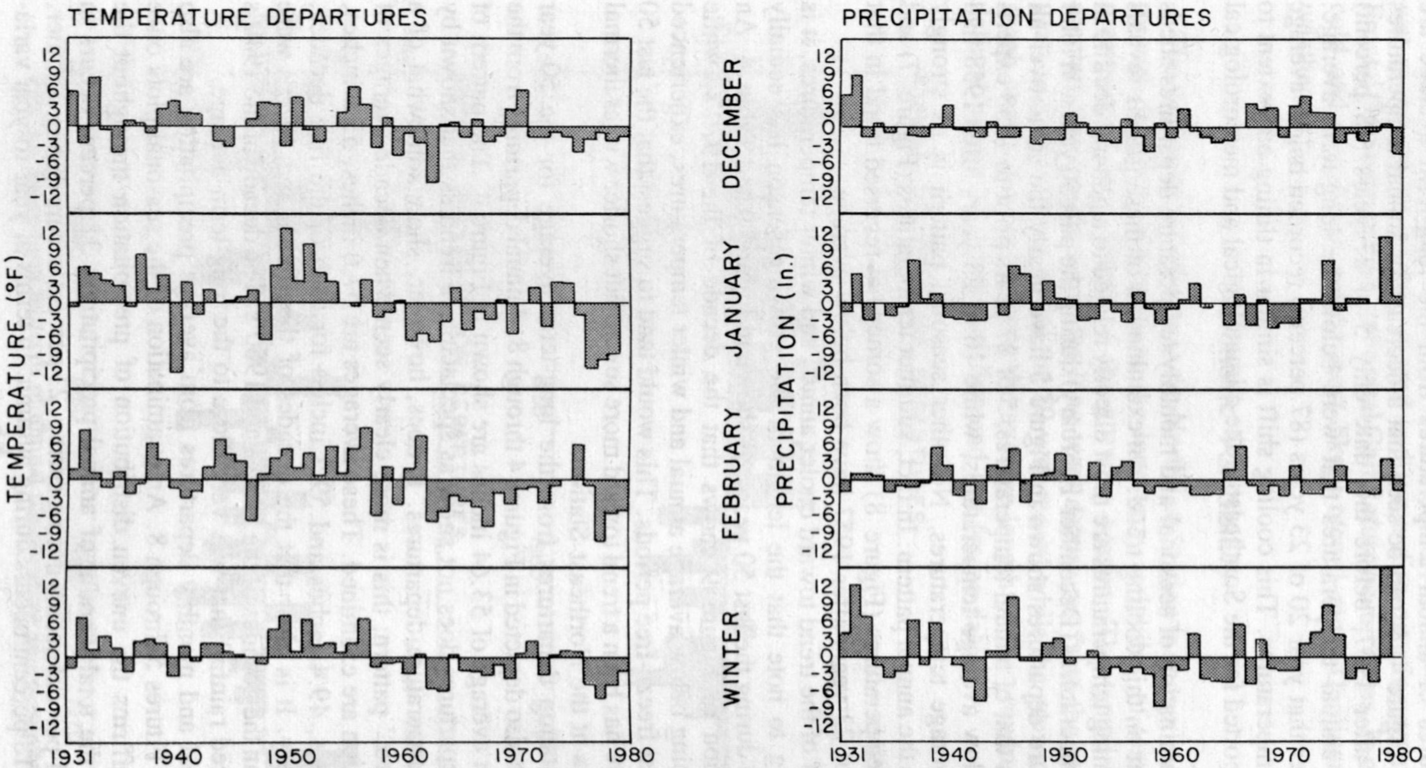


Fig. 5.—Monthly and seasonal departures from long-term average values of temperature and precipitation (winter).

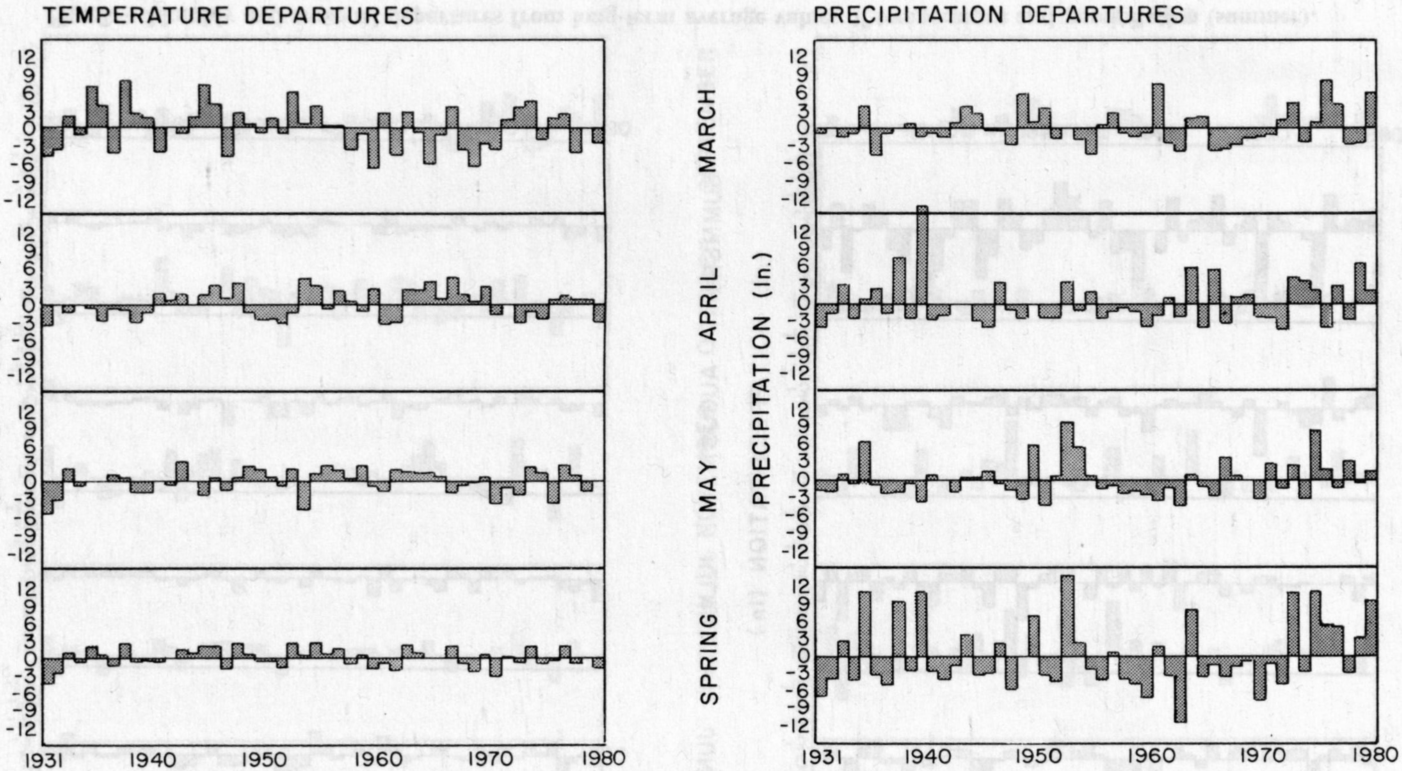


Fig. 6.—Monthly and seasonal departures from long-term average values of temperature and precipitation (spring).

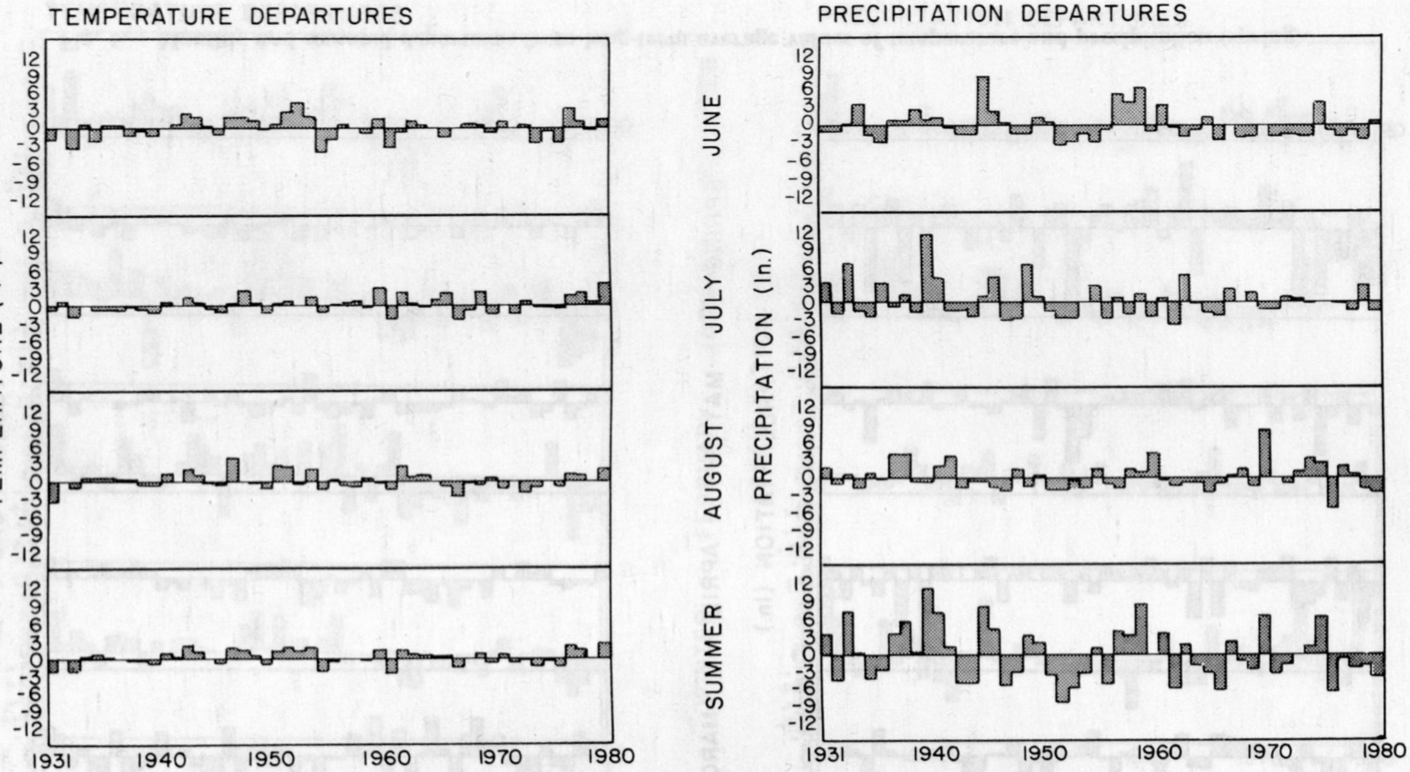


Fig. 7.—Monthly and seasonal departures from long-term average values of temperature and precipitation (summer).

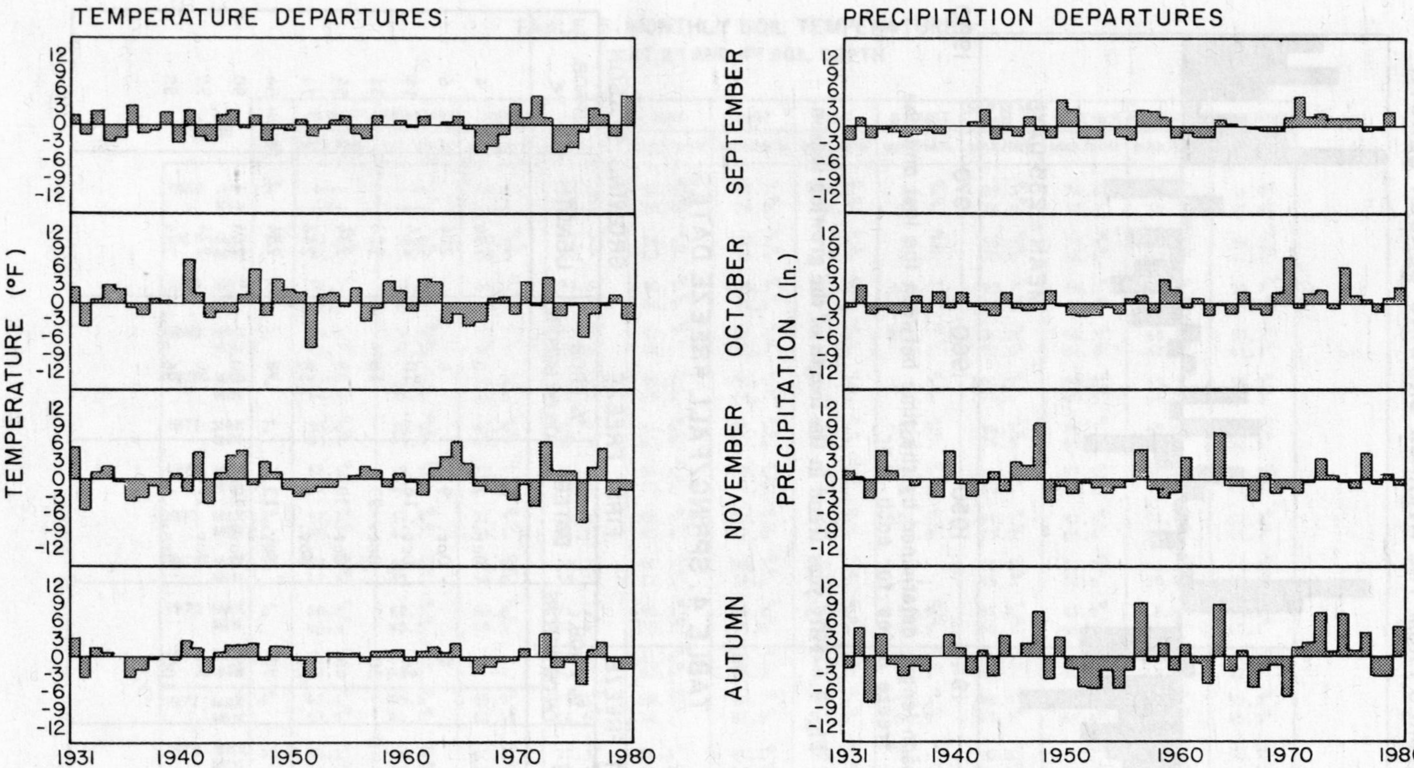


Fig. 8.—Monthly and seasonal departures from long-term average values of temperature and precipitation (autumn).

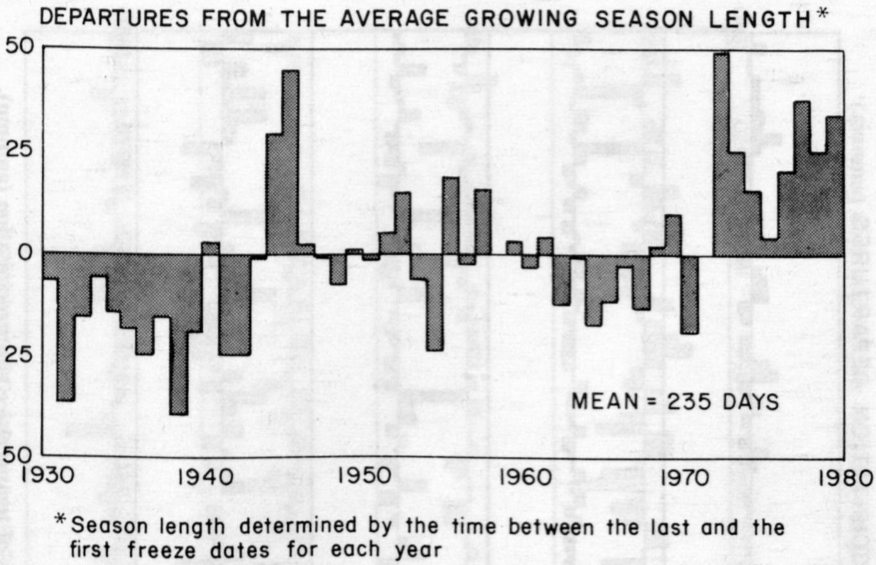


Fig. 9.—Fifty-year trend in the length of the growing season.

TABLE 4. SPRING/FALL FREEZE DATES

LAST FREEZE		FIRST FREEZE		GROWING SEASON	
DATES	% PROB. ON OR BEFORE	DATES	% PROB. ON OR BEFORE	LENGTH	PROB. <
Feb. 14	0	Oct. 2	0	194	4
Feb. 22	4	Oct. 9	6	204	6
Mar. 1	24	Oct. 16	10	214	14
Mar. 8	30	Oct. 23	16	224	34
Mar. 15	46	Oct. 30	38	234	54
Mar. 22	76	Nov. 6	58	244	74
Mar. 29	90	Nov. 13	78	254	84
Apr. 5	96	Nov. 20	90	264	90
Apr. 12	98	Nov. 27	96	274	96
Apr. 19	100	Dec. 4	96	284	98

TABLE 5. MONTHLY SOIL TEMPERATURES
AT 2" AND 4" SOIL DEPTH

YEAR		DEPTH	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
			MAX/MIN	MAX/MIN	MAX/MIN	MAX/MIN	MAX/MIN	MAX/MIN	MAX/MIN	MAX/MIN	MAX/MIN	MAX/MIN	MAX/MIN	MAX/MIN
1966	MAX	2"	----	----	----	79.0°	87.3°	97.7°	100.1°	97.3°	89.5°	74.6°	66.3°	54.0°
	MIN		----	----	----	60.3°	70.0°	78.0°	83.0°	79.7°	74.0°	57.3°	52.5°	43.8°
1967	MAX	2"	51.4°	53.9°	70.6°	82.2°	86.6°	98.2°	97.4°	95.2°	86.9°	79.8°	65.8°	59.2°
	MIN		41.2°	39.6°	54.5°	67.7°	67.7°	79.6°	78.4°	77.7°	70.0°	60.1°	49.8°	47.2°
1968	MAX	2"	51.2°	54.9°	64.7°	79.3°	90.1°	100.3°	102.0°	101.5°	93.7°	88.2°	66.4°	56.7°
	MIN		39.7°	38.7°	46.0°	60.5°	66.9°	77.1°	77.4°	78.0°	69.4°	63.7°	47.7°	39.9°
1969	MAX	2"	54.6°	59.6°	63.7°	82.7°	91.7°	97.6°	103.6°	102.7°	96.8°	84.2°	68.6°	58.1°
	MIN		41.7°	41.9°	42.9°	59.8°	68.3°	76.7°	81.3°	79.1°	72.0°	61.8°	47.2°	41.3°
1970	MAX	2"	----	62.1°	68.3°	81.3°	93.7°	100.4°	101.0°	102.8°	101.2°	80.0°	62.3°	59.3°
	MIN		----	39.9°	49.0°	61.0°	69.9°	76.7°	76.8°	78.0°	74.6°	60.5°	46.7°	49.3°
1971	MAX	2"	53.8°	58.0°	67.6°	81.9°	87.5°	105.1°	106.1°	102.9°	94.7°	86.7°	68.8°	62.7°
	MIN		45.1°	44.9°	47.3°	57.3°	63.9°	77.6°	80.8°	78.3°	74.5°	66.7°	51.5°	51.1°
1972	MAX	2"	58.6°	58.8°	72.5°	86.2°	94.6°	102.6°	104.2°	106.9°	104.4°	83.9°	60.4°	56.7°
	MIN		45.6°	42.3°	51.5°	60.8°	70.2°	78.5°	77.8°	80.8°	80.4°	63.2°	48.1°	42.8°
1973	MAX	2"	52.1°	57.9°	71.5°	76.3°	86.9°	99.2°	105.1°	103.5°	94.2°	87.6°	71.6°	57.4°
	MIN		38.7°	40.7°	54.1°	56.1°	65.8°	77.0°	80.8°	77.8°	75.0°	66.6°	55.5°	41.7°
1974	MAX	2"	59.7°	63.0°	75.6°	79.2°	94.1°	96.3°	102.4°	----	85.5°	81.9°	66.6°	56.8°
	MIN		47.6°	42.7°	56.0°	58.7°	72.5°	74.1°	79.5°	----	69.2°	59.6°	50.9°	43.5°
1975	MAX	2"	60.6°	62.7°	66.8°	74.4°	89.3°	98.8°	100.5°	96.8°	91.8°	81.8°	68.6°	56.1°
	MIN		45.9°	45.5°	49.3°	57.4°	70.7°	75.6°	78.5°	77.9°	69.5°	61.8°	51.3°	43.1°
1976	MAX	2/4"	52.5°	63.8°	----	79.1°	81.4°	89.5°	96.5°	97.4°	88.3°	72.5°	56.7°	51.2°
	MIN		38.5°	48.7°	----	63.4°	67.4°	76.3°	83.1°	75.3°	60.7°	60.7°	47.6°	42.4°
1977	MAX	4"	43.1°	55.6°	66.9°	73.5°	88.8°	96.2°	95.6°	94.2°	88.9°	74.2°	63.8°	53.2°
	MIN		37.5°	44.0°	54.1°	64.0°	74.2°	81.9°	82.5°	80.9°	77.7°	62.4°	55.1°	45.5°
1978	MAX	4"	44.5°	46.9°	60.3°	77.3°	84.4°	94.1°	99.6°	97.1°	90.5°	79.7°	69.2°	56.5°
	MIN		38.9°	37.8°	48.7°	63.0°	71.7°	80.3°	84.9°	83.2°	78.5°	65.6°	60.0°	47.0°
1979	MAX	4"	45.3°	50.0°	66.5°	75.0°	84.7°	89.5°	91.4°	94.8°	86.1°	78.3°	60.4°	51.8°
	MIN		39.4°	41.4°	51.7°	63.5°	71.5°	79.6°	81.4°	84.9°	77.3°	68.6°	52.5°	45.3°
1980	MAX	4"	51.2°	49.6°	59.4°	69.6°	79.2°	89.8°	98.3°	94.2°	87.2°	75.0°	61.6°	53.7°
	MIN		46.9°	43.6°	51.9°	58.1°	71.3°	81.2°	86.6°	86.5°	82.2°	64.1°	53.1°	45.3°

bility, only winter shows the characteristic U-shaped pattern of annual precipitation. All seasons, however, are characterized by a large amount of year-to-year variation in precipitation with spring appearing to be the most variable. The spring pattern of precipitation departures shows a "feast or famine" situation with 31 years of the 50-year record experiencing below average precipitation; but the 19 years experiencing greater than normal precipitation averaged more than 6.4 inches above the spring average.

On the other hand, summer and autumn patterns of precipitation departures are characterized by near equal occurrences of above and below average years. There does, however, tend to be more runs of wet or dry seasons. For example, during the summers of the 1930's, above average precipitation was recorded in seven of the 10 seasons, while in the summers of the 1970's, below average precipitation was recorded in eight of 10 seasons. Moreover, 14 of 20 summers during the 1960's and 1970's experienced below average summer precipitation, a significant trend in light of the relatively small amount of summer precipitation experienced during the average year.

Autumns, likewise, show a tendency toward persistence of above and below average precipitation departures. Runs of four, five and six autumns with below average precipitation are shown in Figure 8, as well as a run of seven seasons with above average precipitation during the 1970's. Interestingly, the summer and autumn patterns are roughly inverse of each other. That is, while summers during the 1930's were experiencing below average precipitation, the autumns experienced above average precipitation with the opposite situation occurring during the 1970's.

Daily Weather Conditions

The daily weather experienced at the Northeast Station is related to the position and intensity of storms associated with the interactions of tropical and continental air masses. During summer and autumn, the interaction boundary, often called the polar front, is usually located well to the north of Louisiana so storm activity is at a minimum. During winter and spring, however, the interaction boundary shifts to a position where storms are both frequent and intense across Louisiana. Both the seasonal shift and seasonal changes in storm intensity are related to changes in the levels of solar radiation intensity in the Northern Hemisphere. During summer, when more equal amounts of solar radiation are delivered to all latitudes in the Northern Hemisphere, storm activity is not intense nor is it frequent in occurrence. The inverse situation is true for winter when greatly different levels of solar radiation are observed and, since storm intensity is derived from the contrasts in temperatures between tropical and polar air masses, storm activity is at a maximum.

Daily weather conditions at the Northeast Station strongly reflect the seasonal factors mentioned above. Data characterizing variations in temperature and precipitation at the station are shown in Tables 6 through 8. The frequency of occurrence of daily maximum and minimum temperatures based on 50 years of continuous daily readings is shown in Table 6. Several trends in the data are significant. First, very little daily temperature variability can be observed in either summer maximums or minimums. During the summer, high temperatures are usually in the lower 90's and upper 80's while the daily low temperatures seldom fall below 70°F. The remarkable constancy in daily thermal conditions is due to the domination of moist tropical air from the Gulf on a nearly continual basis and the absence of frontal activity necessary for cold air intrusions.

In contrast to summer conditions, the winter months show a marked degree of thermal variability. Maximum daily temperatures from December through February occur with near equal frequency from the 40's to the 70's, while daily low temperatures range between the 20's and the 50's (Table 6). This relatively high degree of variability in daily conditions correlates with increases in cold air intrusions associated with frequent cold front passages over Louisiana during the winter.

The characteristic daily thermal conditions experienced during spring and autumn are related to the transitional nature of these two seasons between winter and summer. Early spring is typical of the winter months, while the latter part of spring is typical of the summer months, as shown in Table 6. The reverse pattern is true in autumn.

A second major trend of importance is the occurrence of below freezing temperatures. During winter, when Louisiana weather is characterized by frequent incursions of cold air from the north, below freezing temperatures are not uncommon (Table 6). Below freezing temperatures are experienced at the Northeast Station about 1 in 4 days during December, 1 in 3 days during January, and 1 in 5 days during February. On the average, the last freeze occurs in mid-March and the first freeze occurs generally in the first week in November, allowing an average of 235 freeze-free days per year (Table 4).

An examination of daily temperatures experienced during the 7-month growing season (April through October) shows that 75 percent of all daily high temperatures are over 75°F. Minimum daily temperatures during this period range from the 40's experienced in the early and latter parts of the growing seasons to the lower and middle 70's during the summer months.

The daily precipitation regime at the Northeast Station is organized by months in Tables 7 and 8. Data on the number of raindays (.01 inch or greater), the extreme number of raindays, the number of storm events (defined as a continuous run of raindays), and the average length of a typical storm event are shown in these tables. Also included are probabilities of experiencing given intensity levels of 24-hour rainfall. Probabilities of experiencing a given length of rain-free days after the

TABLE 6. PERCENT FREQUENCY OF OCCURRENCE OF DAILY HIGH AND LOW TEMPERATURE

DAILY HIGH TEMPERATURES

(°F)	J	F	M	A	M	J	J	A	S	O	N	D
>100						*	1	*	*			
91-100				*	7	52	67	67	35	4		
81-90	*	2	11	38	66	44	31	33	50	47	11	1
71-80	20	23	38	43	24	4	2	1	13	36	35	21
61-70	27	30	32	16	3	*			2	12	32	31
51-60	21	27	15	3	*					2	18	28
41-50	18	13	5								5	15
31-40	9	4	1								*	3
21-30	2	*										*
11-20	*											*
1-10												
<=0												

DAILY LOW TEMPERATURES

(°F)	J	F	M	A	M	J	J	A	S	O	N	D
>100												
91-100												
81-90								*				
71-80			*	1	4	38	66	53	28	2	*	
61-70	3	4	9	25	60	54	33	44	53	21	7	3
51-60	12	14	25	42	29	8	1	3	20	35	21	13
41-50	21	26	33	25	6	1			5	29	28	25
31-40	33	35	27	7	*				*	7	30	34
21-30	25	19	5	*						1	13	22
11-20	5	1	*								1	3
1-10	1	*										*
<=0	1											

* LESS THAN .05%

TABLE 7. ANALYSIS OF STORM EVENTS AND INTENSITY OF 24 HR RAINFALL BY MONTH

	AVE. # DAYS PREC.>.01"	EXTREMES LEAST/MOST	AVE. # OF STORM EVENTS	AVE # OF 1 DAY	AVE # OF 2 DAYS	AVE # OF >= 3 DAYS	PROBABILITY OF 24 HR RAIN =>							
							.01"	.2"	.5"	1.0"	1.5"	2.0"	2.5"	3.5"
JAN	10.8	4/21	5.9	3.0	1.8	1.1	.33	.20	.13	.06	.03	.01	.005	.001
FEB	9.2	4/15	5.1	2.6	1.6	0.4	.32	.19	.12	.05	.03	.01	.007	.003
MAR	9.9	4/15	6.0	3.5	1.7	0.9	.31	.19	.06	.03	.02	.01	.01	.003
APR	8.4	4/15	5.0	3.1	1.2	0.8	.27	.16	.10	.05	.03	.02	.01	.005
MAY	8.0	1/15	4.5	2.2	1.4	0.9	.26	.16	.10	.05	.02	.02	.01	.004
JUN	7.6	1/15	4.4	2.6	1.0	0.8	.24	.12	.07	.03	.01	.007	.004	.002
JUL	10.6	4/23	5.2	2.8	1.1	1.3	.32	.17	.09	.03	.02	.01	.01	.001
AUG	8.2	2/15	5.0	2.8	1.2	1.0	.26	.13	.07	.03	.01	.007	.004	.001
SEP	7.6	3/16	4.4	2.4	1.3	0.8	.24	.11	.06	.02	.008	.003	.002	*
OCT	5.3	0/13	3.4	2.0	1.0	0.4	.16	.08	.05	.02	.01	.01	.004	.002
NOV	7.9	1/17	4.7	2.9	1.2	0.6	.25	.15	.10	.04	.02	.01	.005	.002
DEC	10.2	4/19	5.6	3.1	1.3	1.1	.31	.19	.11	.06	.03	.02	.01	.002

occurrence of a rainday or storm event are shown in Table 8.

The basic seasonal patterns of wet and dry mentioned previously can be observed in the tables. Winter and spring show the greatest frequency of both rainday and storm event occurrence while summer and autumn are characterized by a relatively small number of raindays and storm events as well as frequent periods of rather long dry periods except for July. July is an interesting month since, in precipitation characteristics, it appears to be much more like a winter or spring month. During this month northeast Louisiana is generally dominated by very unstable tropical air. When tropical air is subjected to high incomes of solar radiation, and in the absence of strong atmospheric high pressure, instability and updrafts often result in the generation of rather massive thunderstorms with attendent intense episodes of rainfall. The results of these interactive events are seen in the tendency toward relatively high levels of precipitation in July. The presence of high pressure during early summer and autumn acts to suppress the instability inherent to tropical air and, thus, reduced amounts of rainfall are experienced during those months.

The rainfall probabilities in Table 7 show that January (1 day in 3), February (1 day in 3), and July (1 day in 3) have the highest probabilities for

TABLE 8. ANALYSIS OF RAINFREE PERIODS BY MONTH (1931-1980)

	PROBABILITY THAT A RAINFREE PERIOD WILL LAST LONGER THAN (DAYS)											
	3	5	7	9	11	13	15	17	19	21	23	25
JAN	.33	.16	.09	.04	.02	.01	*					
FEB	.37	.19	.08	.04	.03	.01	*					
MAR	.33	.12	.06	.03	.02	.01	*		*			
APR	.44	.24	.10	.06	.03	.01	*	*				
MAY	.49	.30	.17	.11	.05	.04	.03	.01	.01	.01	*	*
JUN	.44	.29	.18	.11	.07	.04	.03	.02	.02	.01	*	*
JUL	.35	.21	.12	.05	.03	.02	.01	*	*			
AUG	.42	.25	.17	.10	.05	.03	.02	.02	.01	*	*	*
SEP	.47	.28	.20	.12	.08	.06	.03	.01	.01	*		
OCT	.60	.41	.29	.22	.19	.13	.09	.08	.06	.04	.03	.01
NOV	.41	.25	.14	.08	.03	.03	.01	.01	*	*		
DEC	.40	.18	.10	.04	.01	*	*					

* LESS THAN .005

rainday occurrence. The driest month, by far, is October (1 day in 6), although May, June, August, September, and November show relatively low rainday probabilities. Intense 24-hour rainfall episodes are most likely to occur during April, although all months show potentials for recording rather large amounts of rainfall during a 24-hour period.

The length of rainfree periods between storms is shown in Table 8. These data show the probability of having a rainfree period longer than 3 days is about 1 in 3 during January, March, and July, suggesting that these months are very nearly always wet. In contrast, the months of April, May, August, and September show stronger tendencies for longer rainfree periods, indicating more widely spaced rainfall episodes. During May, June, August, and September, 1 in 5 storm events will be followed by a rainless period of at least 1 week. This suggests a significant wetting and drying cycle during these months.

Evaporation and Climatic Water Budget

Perhaps two of the most important parameters to agricultural production are the rate of evaporation and the level of available soil moisture through the growing season at a given location. Data on the rate of evaporation and the climatic water budget at the Northeast Station are included in Tables 9 through 11 and Figures 10 through 12. Since data on measured soil evaporation, plant transpiration, and soil moisture status are limited to a relatively short record of pan evaporation, the climatic water budget was constructed using the Thornthwaite method (1948). This method allows for calculation of water budget components using the established temperature and precipitation record for a given station. Although the derived components are only estimates of actual conditions, the climatic water budget allows further insight into climatic conditions.

The limited record of open pan evaporation at the Northeast Station is shown in Table 9. While limited, it does suggest the seasonal regime of moisture demand. Using 1980 as a "typical" year, the data show that very high rates of evaporation are experienced during the peak of the growing season (greater than 8 inches per month), somewhat lower rates are experienced during spring and autumn, with relatively low rates of pan evaporation occurring during winter. The seasonal regime essentially follows the seasonal patterns of solar radiation and temperature but does not correspond to the seasonal pattern of precipitation.

Monthly precipitation during the 7-month growing season is usually well below the rate of pan evaporation, as can be seen by comparing Table 1 with Table 9. A comparison of Table 9 with Table 10 shows that probabilities of receiving amounts of precipitation below that necessary to satisfy evaporative demand are very high. During the summer months the probability of receiving less precipitation than that needed to match pan

TABLE 9. MONTHLY PAN EVAPORATION (IN.)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1960								5.47	4.97	3.46	2.58	2.23
1961	1.76	2.31	4.39	5.94	6.89	6.15	6.50	6.75	5.73	4.53	2.83	----
1962	----	----	----	4.43	8.40	6.97	8.93	8.35	5.99	4.68	2.53	----
1970												
1971												
1972												
1973												
1974												
1975												
1976	----	----	----	----	----	6.82	7.37	7.77	5.52	4.51	2.47	1.41
1977	0.36	3.75	4.67	5.99	8.05	10.96	7.51	6.73	5.33	4.82	3.09	1.38
1978	----	----	3.90	6.73	6.84	7.76	8.68	7.16	5.40	5.59	3.15	1.33
1979	----	0.80	4.68	4.68	6.69	7.82	6.64	6.86	5.86	5.78	----	0.84
1980	1.05	1.18	2.75	5.14	6.09	8.09	8.52	8.74	6.18	5.21	2.90	1.29

TABLE 10. MONTHLY PRECIPITATION PROBABILITIES

CUMULATIVE PROBABILITY OF RECEIVING MONTHLY RAINFALL

RAINFALL (INCHES)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
<0.5	0	0	0	0	1	3	0	2	8	12	3	0
<1.0	0	2	0	3	3	10	2	10	25	26	8	1
<1.5	1	3	3	11	9	20	4	22	29	45	11	2
<2.0	7	4	6	14	13	32	19	32	44	52	22	2
<2.5	15	12	9	21	15	49	24	46	52	56	24	2
<3.0	26	26	11	38	25	57	42	52	58	60	35	8
<3.5	30	35	21	41	34	61	44	60	65	66	46	18
<4.0	33	42	24	44	43	70	46	67	70	72	57	37
<4.5	41	55	31	53	52	75	57	72	83	82	66	42
<5.0	47	57	49	57	58	81	66	81	85	89	71	50
<6.0	57	64	58	61	73	84	78	87	96	93	79	63
<8.0	82	85	76	77	87	93	87	98	100	95	85	78
<10.	87	89	86	89	89	99	93	99	100	99	95	92
<12.	92	92	91	96	95	100	98	100	100	100	96	99

TABLE 11. PROBABILITIES THAT VARIOUS AMOUNTS OF SOIL MOISTURE DEFICIT AND SURPLUS WILL OCCUR

BASED ON AN ESTIMATE OF 6" OF SOIL MOISTURE STORAGE

MONTH	DEFICIT								SURPLUS							
	AVE	PROBABILITY OF DEFICIT =>							AVE	PROBABILITY OF SURPLUS =>						
		0.1"	1"	2"	3"	4"	5"	6"		0.1"	2"	4"	6"	8"	10"	12"
JAN									4.43"	100	70	52	24	16	10	2
FEB									3.96"	98	80	40	22	8	2	
MAR									4.45"	96	82	52	24	12	8	2
APR	0.04"	18							3.08"	92	50	34	20	8	4	2
MAY	0.32"	64	6						2.05"	88	24	16	10	6	2	2
JUN	1.31"	100	60	16	6				0.76"	80	12	6	2			
JUL	2.24"	94	80	58	24	10	2		0.72"	92	6	2	2	2		
AUG	2.66"	100	86	64	42	20	8		0.40"	86	2					
SEP	2.18"	100	76	54	28	8			0.30"	76						
OCT	1.34"	94	62	22	2				0.46"	66	4	2				
NOV	0.22"	48							1.06"	83	14	6	4			
DEC	0.04"	10							2.92"	98	50	28	16	8	4	2
ANNUAL	10.35"								24.59"							

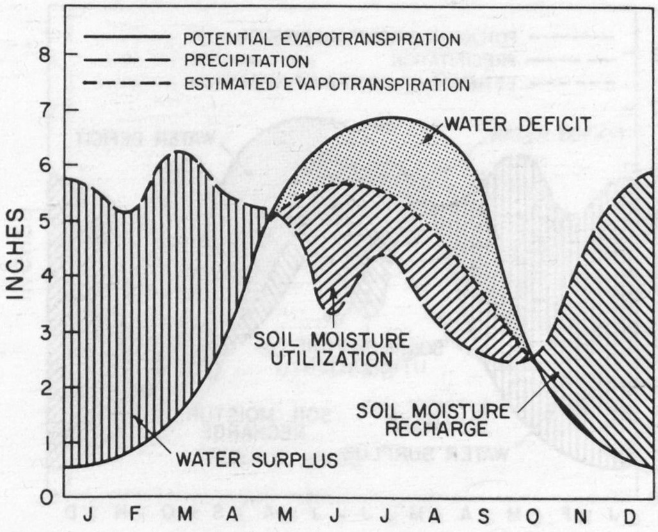
evaporation is about 90 percent each month. In fact, when the entire growing season is examined, no month shows very high probabilities of receiving sufficient precipitation. The inverse situation is true for the 5 months outside the growing season (November-March). These facts suggest that the climate at the Northeast Station experiences strong moisture surplus and moisture deficit periods.

To examine the seasonal regime of moisture surplus and deficit for the 50-year record, the Thornthwaite model was used to generate estimates of potential evapotranspiration (PE), evapotranspiration (ET), soil moisture deficit (DEF), soil moisture surplus (SUR), soil moisture utilization (SMU), and soil moisture recharge (SMR). Potential evapotranspiration (PE), an index of evaporative demand, is defined as the maximum amount of soil evaporation and plant transpiration that can occur from a well watered soil plant system. PE is dependent on such factors as solar radiation, daylength, and temperature. A comparison of the data in Figure 10, which shows monthly and yearly estimates of PE, to the pan evaporation data in Table 9 suggests that while the seasonal regimes of PE and pan evaporation are similar, the gross amounts are not, especially during summer. It is well known that evaporation pans are somewhat like wicks or oases in the landscape and thus tend to overestimate rates of evapotranspiration. The Thornthwaite PE model attempts to compensate in part for the higher values of pan evaporation.

Annual estimated PE at the Northeast Station has averaged 41.3 inches per year, which is some 12 inches less than annual precipitation. It would seem at first glance that sufficient moisture should be available to match rates of PE. However, when seasonal match-ups of PE and precipitation are made a different picture emerges. During winter, 16.4 inches of precipitation is received compared with about 3 inches of PE; during spring, about 17 inches of precipitation is received compared with about 10 inches of PE; during summer, about 11 inches of precipitation is received compared with about 20 inches of PE; and, finally, in autumn about 10 inches of precipitation is received compared with about 10 inches of PE. Stated another way, this means precipitation is roughly five times greater than PE in winter, almost two times greater in spring, nearly half as much during summer, and equal in autumn. These comparisons of seasonal precipitation with PE show that the climate at the Northeast Station is composed of two distinctly different periods. The first period occurs during winter and spring when seasonal precipitation exceeds evaporative demand, while the second period occurs during summer and autumn when evaporative demand exceeds or is equal to seasonal precipitation.

The long-term average monthly climatic water budget, shown in Figures 10 through 12, shows this pattern of alternate surplus (S) and deficit (D) periods more clearly. The PE data, derived using the Thornthwaite methodology, when compared with the average monthly precipitation regime, allows for calculation of the other water budget components mentioned previously. When precipitation exceeds PE during any month a potential surplus exists. This situation generally exists in January, February, March, April, November, and December. On the other hand, when PE exceeds precipitation, a potential deficit exists. This situation exists generally during May through October. The occurrences of moisture surplus and deficit conditions are very important since surplus situations can be related to nutrient leaching, excess soil moisture, and soil erosion, while deficits can be related to moisture stress in crops.

The severity of the moisture surplus and deficit is somewhat moderated by soil and vegetation characteristics, principally through storage of moisture within the soil profile and its ultimate withdrawal during periods of need. The actual amount of soil moisture storage is highly variable, depending on such factors as soil texture, soil depth, crop type and rooting behavior. To depict climatic water budget conditions for the region surrounding the Northeast Station, estimates of soil moisture storage capacity at 4-inch, 6-inch, and 12-inch depths are assumed in order to simulate the variable soil conditions found within the region. The 4-inch estimate is suggested as typical of upland terrace soils, while 12 inches is more typical of the region's alluvial soils. The 6-inch estimate is a climatic standard used



AVERAGE CLIMATIC WATER BUDGET DATA*

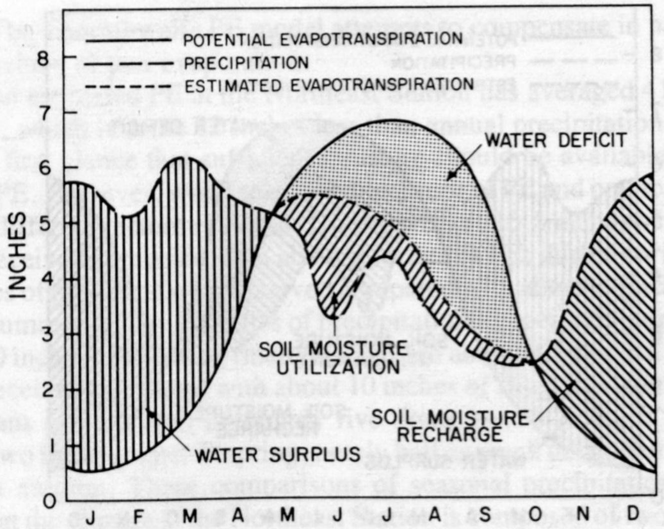
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
PE	0.53	0.71	1.46	2.93	5.48	6.27	6.86	6.72	5.72	2.66	1.25	0.72	41.31
PREC	5.68	5.04	6.13	5.34	5.04	3.37	4.48	3.27	2.72	2.61	4.32	5.64	53.65
ET	0.53	0.71	1.46	2.93	5.47	5.54	5.62	4.30	3.22	2.62	1.25	0.72	34.37
SURP	5.15	4.33	4.67	2.41	0	0	0	0	0	0	0	2.74	19.30
DEF	0	0	0	0	0.01	0.73	1.24	2.42	2.50	0.04	0	0	6.94
SMU	0	0	0	0	0.41	2.17	1.14	1.03	0.50	0.01	0	0	5.26
SMR	0	0	0	0	0	0	0	0	0	0	3.07	2.19	5.26

*ALL UNITS ARE IN INCHES OF WATER

Fig. 10.—Long-term average climatic water budget assuming 6 inches of soil moisture storage.

The symbols PE, PREC, ET, SURP, DEF, SMU, SMR in Figures 10-12 stand for potential evapotranspiration, precipitation, evapotranspiration, surplus soil moisture, deficit soil moisture, soil moisture utilization, and soil moisture recharge, respectively.

principally to compare locations without regard for inherent soil differences. In all cases the moisture stored within the soil profile is assumed to be decreasingly available as the soil moisture is depleted. That is, as an increment of soil moisture is withdrawn from the soil profile, more energy is required to withdraw the next increment. It is important to recognize that not all soil moisture will be available to crops during dry periods.



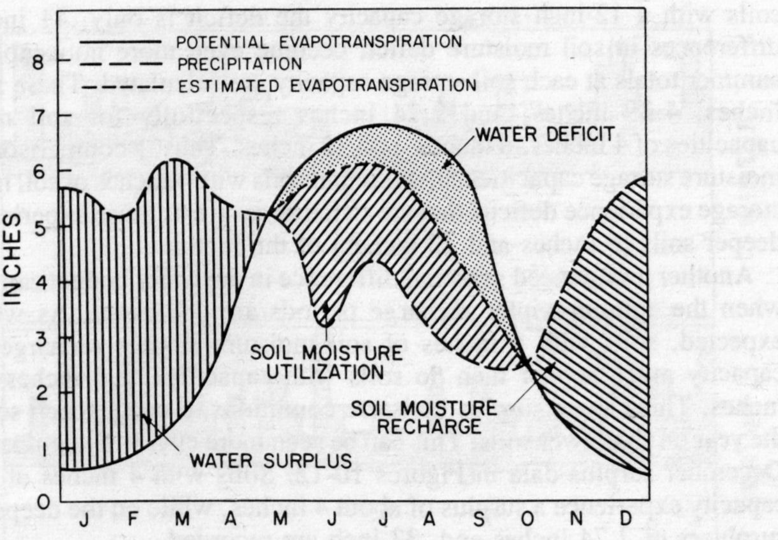
AVERAGE CLIMATIC WATER BUDGET DATA*

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
PE	0.53	0.71	1.46	2.93	5.48	6.27	6.86	6.72	5.72	2.66	1.25	0.72	41.32
PREC	5.68	5.04	6.13	5.34	5.04	3.37	4.48	3.27	2.72	2.61	4.32	5.65	53.65
ET	0.53	0.71	1.46	2.93	5.47	5.26	5.18	3.80	2.91	2.61	1.25	0.72	32.83
SURP	5.15	4.33	4.67	2.41	0	0	0	0	0	0	0	4.26	20.82
DEF	0	0	0	0	0.01	1.01	1.68	2.92	2.81	0.05	0	0	8.48
SMU	0	0	0	0	0.43	1.89	0.70	0.53	0.19	0	0	0	3.74
SMR	0	0	0	0	0	0	0	0	0	0	3.74	0	3.74

*ALL UNITS ARE IN INCHES OF WATER

Fig. 11.—Long-term average climatic water budget assuming 4 inches of soil moisture storage.

A comparison of Figures 10 through 12 shows that significant differences can be observed in water budget components except for values of PE and precipitation. Principal differences lie in the increased severity of soil moisture deficit and surplus as soil moisture storage varies from 12 inches to 4 inches. Likewise, the level of estimated evapotranspiration (ET), that moisture which is evaporated and transpired from the soil-plant system to the atmosphere, is reduced in accordance with the increase in soil moisture deficit. This factor is very important since research has shown that ET is highly correlated with levels of agronomic productivity.



AVERAGE CLIMATIC WATER BUDGET DATA*

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
PE	0.53	0.71	1.46	2.93	5.48	6.27	6.86	7.72	5.72	2.66	1.25	0.72	41.31
PREC	5.68	5.04	6.13	5.34	5.04	3.37	4.48	3.27	2.72	2.61	4.32	5.65	53.65
ET	0.53	0.71	1.46	2.93	5.47	5.86	6.11	5.14	3.95	2.63	4.32	5.65	44.76
SURP	5.15	4.33	4.67	2.41	0	0	0	0	0	0	0	0.33	17.89
DEF	0	0	0	0	0.01	0.41	0.75	1.58	1.77	0.03	0	0	4.54
SMU	0	0	0	0	0.43	2.49	1.63	1.87	1.23	0.02	0	0	7.67
SMR	0	0	0	0	0	0	0	0	0	0	3.07	4.60	7.67

*ALL UNITS ARE IN INCHES OF WATER

Fig. 12.—Long-term average climatic water budget assuming 12 inches of soil moisture storage.

The seasonal regimes of the water budget depicted in Figures 10-12 are similar, yet show significant differences in absolute quantities of the various water budget components. During the period when precipitation exceeds PE and the soil moisture storage is at capacity, no differences exist (January-April). Significant differences in the three figures begin to appear in early summer when high evaporative demand causes soil moisture to be extracted at increasing rates. A comparison of June soil moisture deficits, for example, shows that on soils with a 4-inch storage capacity the deficit is 1.01 inches; on soils with 6-inch storage capacity the deficit is .73 inch; on soils with a 12-inch storage capacity the deficit is only .41 inch. The differences in soil moisture deficit become even more noticeable when summer totals at each soil storage capacity are calculated. These are 5.61 inches, 4.39 inches, and 2.74 inches respectfully for soil moisture capacities of 4 inches, 6 inches, and 12 inches. Thus, a comparison of soil moisture storage capacities suggests that soils with 4 inches of soil moisture storage experience deficits that are twice as severe as those experienced on deeper soils (6 inches and 12 inches) of the region.

Another pronounced seasonal difference in the water budget can be seen when the autumn-winter recharge periods are compared. As would be expected, soils with 4 inches of soil moisture storage recharge to full capacity much sooner than do soils with capacities of 6 inches and 12 inches. This causes surplus moisture conditions to occur much sooner in the year on shallower soils. This can be seen more clearly by comparing the December surplus data in Figures 10-12. Soils with 4 inches of storage capacity experience a surplus of about 4 inches, while on the deeper soils, surpluses of 2.74 inches and .33 inch are recorded.

Long-Term Patterns of Surplus and Deficit Soil Moisture

The long-term patterns of seasonal soil moisture surplus and deficit are shown in Figure 13. This figure was developed by using the Thornthwaite water budget method to calculate daily estimates of soil moisture conditions assuming 6 inches of soil moisture storage. Of course, moisture conditions will vary on deeper or shallower soil common to the regions and interpretation of Figure 13 should be adjusted accordingly.

It should be noted that use of daily estimates of soil moisture conditions will give somewhat different estimates than those derived using monthly budgets (Figures 10-12). This occurs because the monthly budget assumes a uniform rainfall distribution during a given month while the daily budget takes into account individual rainfall occurrences and rainfree periods. Thus, while the monthly budget shows a month to be experiencing only a surplus, deficit *or* recharge moisture condition, the daily budget may show occurrences of surplus, deficit *and* recharge during the same month.

Periods of moisture surplus and deficit occur in all four seasons, although the occurrence of deficit is rather unusual and never severe in winter, as shown in Figure 13. The seasonal regimes of surplus and deficit shown in Figures 10 through 12 for the average monthly water budget can be seen as well in the daily water budgets. Once again, winter and spring show up as distinct seasons of soil moisture surplus, while summer and autumn show up as seasons of soil moisture deficit. An important difference between average monthly and daily water budgets is the occurrence of significant deficits during spring as well as significant surplus moisture during summer and autumn. Clearly the occurrence of these situations

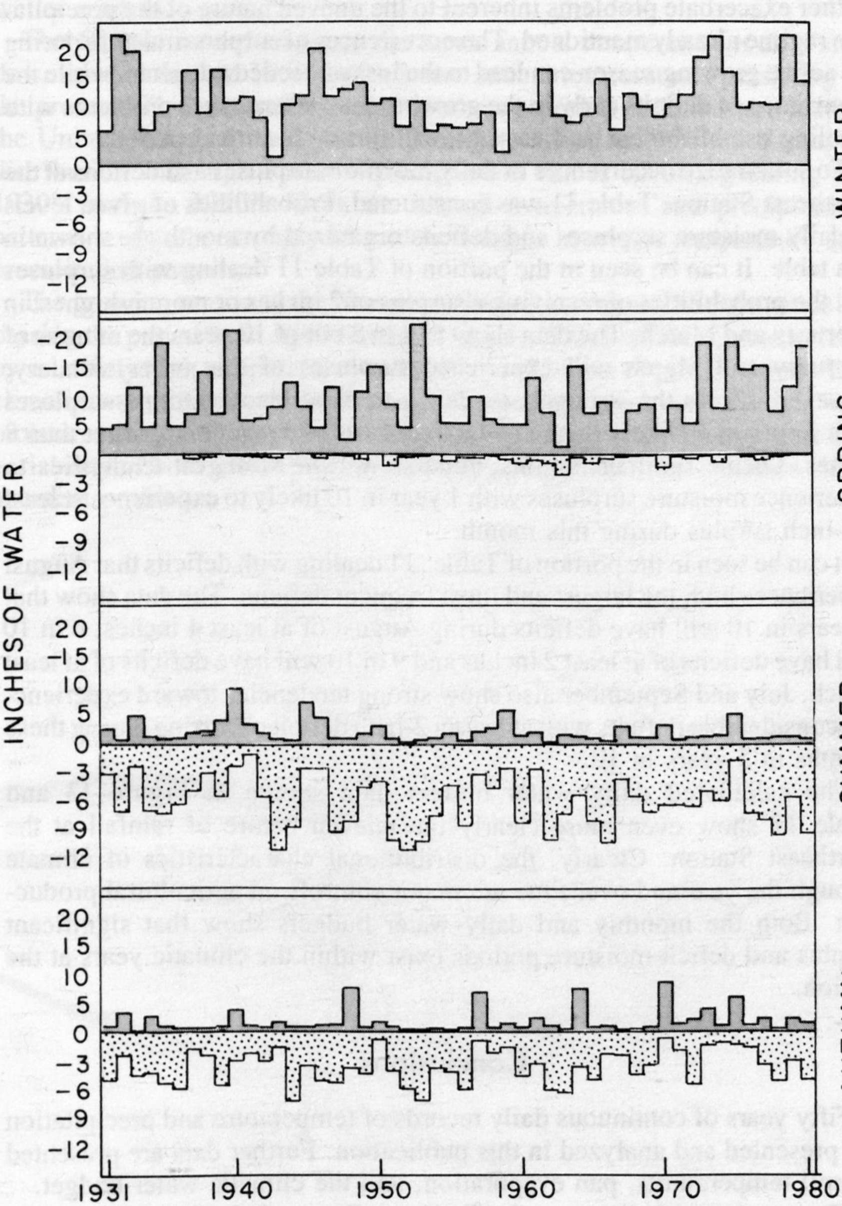


Fig. 13.—Surplus/deficit of soil moisture by season assuming 6 inches of soil moisture storage. (Data based on 50 years of continuous daily water budgets; values differ somewhat from those in Fig. 10-12.)

further exacerbate problems inherent to the uneven nature of the precipitation regime already mentioned. The occurrences of surplus moisture during the active growing season can lead to the loss of needed nutrients, while the occurrence of deficits early in the growing season can cause problems with seedling establishment and crop growth during a critical period.

To summarize occurrences of daily moisture surpluses and deficits at the Northeast Station, Table 11 was constructed. Probabilities of given levels of daily moisture surpluses and deficits organized by month are shown in this table. It can be seen in the portion of Table 11 dealing with surpluses that the probabilities of receiving a surplus of 2 inches or more is highest in February and March. The data show that in 8 out of 10 years the months of February and March will experience surpluses of this order. January, however, shows the strongest tendency to experience extreme surpluses with 1 year in 10 likely to have a January surplus equal to or greater than 8 inches. Of the summer months, June shows the strongest tendencies to experience moisture surpluses with 1 year in 10 likely to experience at least a 2-inch surplus during this month.

It can be seen in the portion of Table 11 dealing with deficits that August experiences both the largest and most frequent deficits. The data show that 2 years in 10 will have deficits during August of at least 4 inches, 6 in 10 will have deficits of at least 2 inches and 9 in 10 will have deficits of at least 1 inch. July and September also show strong tendencies toward experiencing considerable deficits with at least a 2-inch deficit occurring during these months in 5 years in 10.

The calculated daily water budget data shown in Figure 13 and Table 11 show even more clearly the uneven nature of rainfall at the Northeast Station. Clearly, the distributional characteristics of climate through the year and over time are major controls on agricultural production. Both the monthly and daily water budgets show that significant surplus and deficit moisture periods exist within the climatic years at the station.

Conclusions

Fifty years of continuous daily records of temperature and precipitation are presented and analyzed in this publication. Further data are presented on soil temperatures, pan evaporation, and the climatic water budget.

The weather and climate at the Northeast Research Station, as shown in the collected data, display regimes of climatic resources typical of much of the southeastern region of the continental United States. The relatively low-latitude location, coupled with nearby sources of atmospheric moisture, provide for a bountiful income of both solar radiation and precipitation annually. On average, therefore, the Northeast Station experiences a humid, subtropical climate with long, humid summers and much cooler, wetter winters.

The 50-year record suggests the mean annual temperature took a step downward in the late 1950's with lower annual temperatures persisting to the present. This pattern is similar to others reported in the eastern half of the United States. Annual precipitation has tended to follow a U-shaped distribution with higher annual precipitation values occurring during the 1930's and the 1970's. Both the annual temperature and precipitation patterns tend to be strongly related to changes in winter temperature and precipitation patterns.

The growing season at the Northeast Station averages 235 days, encompassing the period from April through October. This period is characterized by relatively high temperatures and reduced amounts of precipitation. The climatic water budget shows that significant occurrences of deficient soil moisture are quite common during the growing season, and that the variability of both deficits and surpluses present significant resource management problems.

TABLE 12. AVERAGE MONTHLY TEMPERATURES (°F)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN. MEAN
1931	47.0	52.6M	52.6	61.8	67.2	77.4	80.6	76.4	77.8	68.4	61.5	56.1	65.0
1932	54.2	59.6	53.6	65.5	69.6	79.3	82.2	81.0	74.4	61.7	51.6	46.7	65.0
1933	52.8	51.8	59.6	64.0	75.1	75.7	79.6	78.8	78.6	66.4	57.2	58.6	67.6
1934	51.4	49.4	56.0	65.7	71.6E	79.9E	81.4	81.7	73.2	69.0	57.8	49.1	66.6
1935	50.7	52.4	64.8	65.0	71.8	77.0	80.6	81.6	73.9	68.2E	55.4	45.2	65.5
1936	46.8	48.2	61.2	62.6	73.0	79.7	80.8	81.8	79.6	65.1	52.2	50.7	65.1
1937	56.3	50.4	52.8	65.0	73.9	76.6	80.4	81.4	74.8	63.9	52.8	50.2	65.1
1938	50.0	57.6	66.0	64.5	73.4	78.0	81.4	81.3	75.3	66.4	54.8	48.6	66.4
1939	52.5	54.2	59.8	62.4	70.9	78.7	81.0	79.4	78.4E	66.2	53.4	53.0	65.8
1940	35.2	49.3	59.1	64.2	70.9	78.0	80.4	79.5	73.0	65.8	56.8	54.4	63.9
1941	51.4	47.6	53.1	67.6	73.1	79.4	82.0	82.5	78.8	73.3	53.6	52.2	66.2
1942	45.4	48.9	57.8	66.2	72.1	79.4	81.5	81.0	74.2	67.0	60.6	52.0	65.5
1943	50.2	53.0	56.5	67.4	76.4	81.7	83.0	83.2	73.6	63.2	51.8	49.8	65.8
1944	47.7	58.0	59.4	65.3	72.9	81.0	81.9	82.0	78.0	64.4	57.0	47.0	66.2
1945	48.1	55.2	65.2	67.2	70.2	79.4	81.0	80.7	78.8	64.2	60.1	46.4	66.4
1946	48.7	53.9	61.5	68.9	72.0	78.2	80.4	80.4	75.6	67.2	60.7	54.0	66.8
1947	49.8	43.8	52.1	66.6	71.3	81.0	81.8	84.8	77.8	71.4	55.0	51.2	65.5
1948	41.1	51.8	60.3	69.5	73.6	81.1	83.9	80.9	73.5M	63.5	58.9M	54.1	66.0
1949	54.4	54.7	58.1	64.0	75.5	80.4	81.8	80.7	75.9	69.9	57.0	53.7	67.2
1950	61.2	56.2	56.5	62.7	75.0	78.9	80.1	79.8	75.2	68.2	54.3	46.5	66.2
1951	51.4	52.7	59.3	63.0	73.4	79.8	81.9	83.8	77.0	67.5	52.8	54.9	66.5
1952	58.3	55.7	56.6	62.5M	72.0	82.0	82.3	83.5	74.3	58.0	54.0	49.5	65.7
1953	53.1M	51.3	64.0	64.4	75.0	83.5	81.3	80.5	75.6	67.2	54.7	47.5	66.5
1954	51.6	56.8	58.2	70.3	67.7	30.9	83.0	83.1	77.0	67.4	54.8	50.2	66.7
1955	47.9	51.7M	61.5	68.5	74.1	75.1	80.2	79.6	77.8	64.9	56.2	52.1M	65.8
1956	47.3	56.4	57.7	64.7	75.5	77.2	81.7	81.2	74.7	68.4	56.4	57.0	66.5
1957	51.9	60.1	57.8	68.0	74.6	79.9	81.9	80.8	74.0	62.7	58.1	52.5	66.9
1958	45.2	44.5	53.6	65.8	72.9	79.4	82.2	80.0	78.0	64.9	58.1	53.5	66.9
1959	46.0	53.2	56.7	64.3	75.6	78.4	81.3	81.4	76.4	69.5	54.5	51.4	65.7
1960	48.3	46.4	50.3	68.3	71.9	81.0	84.5	80.7	76.8	67.7	56.8	44.8	64.8
1961	41.4	52.7	60.4	61.9	71.2	75.9	79.1	79.4	75.9	64.2	55.6	48.8	63.9
1962	42.5	58.6	52.4	62.3	74.8	78.5	83.6	83.4	78.1	69.8	53.2	47.0	65.4
1963	40.8	43.6	60.6	68.1	74.4	80.5	81.6	81.7	76.2	69.1	57.7	39.9	64.5
1964	44.6	45.3	56.9	67.9	74.1	79.6	81.3	82.0	76.5	62.1	59.7	50.2	65.0
1965	50.7	48.2	51.1	69.6	74.4	79.0	82.4	80.9	78.0	64.0	62.3	50.3	65.9
1966	42.9	47.2	56.2	66.4	73.3	77.4	83.6	80.1	75.6	62.0	58.5	47.9	64.3
1967	46.5	46.0	64.1	70.4	70.7	79.5	78.9	78.3	71.6	62.5	54.9	51.3	64.3
1968	44.8	42.6	53.5	67.0	72.2	79.9	80.6	80.8	72.7	66.6	53.8	47.3	63.5
1969	48.2	48.6	50.6	65.8	72.6	79.7	83.9	80.3	74.6	66.8	53.9	48.5	64.5
1970	42.2	46.5	55.1	68.7	73.2	78.6	79.8	81.5	79.8	63.7	52.6	53.0	64.6
1971	47.8	49.4	52.7	63.6	68.7	80.2	81.5	79.4	77.2	69.4	55.5	56.6	65.2
1972	50.5	49.7	59.0	65.7	71.9	79.2	79.8	81.2	81.2	65.3	51.6	48.0	65.3
1973	43.6	61.3	62.3	62.2	70.3	79.7	82.3	79.2	77.4	70.3	62.3	48.1	65.3
1974	51.4	50.0	62.4	64.2	75.3	76.5	81.1	79.9	71.4	63.3	57.1	49.0	65.2
1975	51.2	51.1	55.5	62.9	74.1	78.9	81.1	80.7	72.6	65.4	57.1M	48.2	64.9
1976	45.6	57.1	59.5	66.3	68.2	76.9	80.9	80.8	75.0	59.7	48.4	45.5	63.6
1977	36.3	49.8	60.2	66.9	75.6	82.6	83.3	82.1	79.2	64.0M	58.1	47.8	65.5
1978	37.8	40.1	52.0	66.2	73.4	80.2	83.6	81.9	77.9	65.4	61.3	49.0M	64.2
1979	39.0	45.1	57.7	66.4	71.1	78.9	81.9M	80.8	74.3	67.1	53.3	47.3	63.6
1980	48.1	45.6	54.8	62.4	73.0	80.7	75.2	83.1	81.3	62.9	54.1	48.1	64.9

***The letter M in Table 12 indicates missing data during that month. Calculated averages are based on the existing record.**

TABLE 13. TOTAL MONTHLY PRECIPITATION (IN.)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1931	4.06	3.00	5.14	1.36	3.22	2.22	7.69	4.80	0.22	1.65	5.67	11.47	50.50
1932	11.01	6.29	6.00	3.78	2.92	2.46	2.23	2.04	4.25	5.60	4.55	14.72	65.85
1933	2.34	6.20	4.48	8.60	6.06	3.63	11.10	3.79	0.48	0.36	0.75	2.67	51.46
1934	5.52	5.80	5.42	2.59	4.46	7.07	2.92	1.33	2.42	1.36	9.37	6.24	54.50
1935	3.36	3.03	10.17	5.87	11.73	1.57	1.74	3.88	1.67	0.65	5.53	4.56	53.76
1936	5.16	4.20	1.17	7.85	4.19	0.81	4.81	3.09	0.78	1.00	4.35	5.76	43.17
1937	13.26	3.75	5.31	4.09	2.80	4.07	3.38	7.44	1.20	3.82	2.86	4.04	56.02
1938	6.14	4.70	5.94	13.03	3.02	3.99	5.97	7.43	1.97	0.76	4.15	3.97	61.07
1939	7.23	10.97	6.63	2.07	4.91	6.05	2.87	2.43	1.22	4.49	0.87	5.90	56.27
1940	2.89	7.48	4.53	21.80	1.22	4.18	16.04	2.35	2.76	1.39	9.23	9.57	83.44
1941	2.83	2.39	5.29	2.47	5.96	4.63	8.44	5.10	2.86	4.39	3.51	5.10	52.97
1942	2.65	4.23	4.31	3.20	5.02	2.90	2.58	6.86	3.34	1.89	1.27	4.94	43.19
1943	2.73	0.81	7.12	4.96	2.97	1.83	2.87	1.25	5.58	1.21	3.57	3.97	38.87
1944	5.62	7.67	9.97	5.03	5.39	1.71	1.77	2.64	0.42	0.03	5.53	6.47	52.25
1945	3.59	7.04	8.51	2.36	5.43	11.50	5.29	2.45	2.31	4.26	1.94	3.82	58.50
1946	12.17	10.48	5.69	1.32	6.55	5.46	8.43	1.36	0.82	1.37	7.20	3.75	64.60
1947	10.88	1.08	5.58	8.81	4.50	3.56	1.13	1.13	4.31	1.03	6.42	5.51	53.94
1948	4.34	6.04	3.35	4.15	3.39	1.89	1.61	4.54	1.37	1.36	14.10	2.73	49.34
1949	9.68	6.14	12.22	2.72	1.63	2.01	10.78	1.51	0.57	4.90	0.06	3.51	55.73
1950	6.42	9.78	7.05	5.41	11.18	4.66	5.08	3.47	7.40	2.20	3.22	3.43	69.30
1951	6.17	5.43	9.75	2.81	0.71	3.80	2.70	0.91	5.33	0.25	1.77	8.23	47.86
1952	2.65	5.25	3.96	2.86	5.55	0.09	1.72	0.89	0.48	0.00	3.84	6.21	33.50
1953	2.93	8.14	6.22	8.89	15.29	0.71	1.86	2.95	0.63	0.51	2.79	4.57	55.49
1954	6.24	2.19	4.00	4.02	10.59	2.00	4.56	1.14	3.07	2.06	1.88	3.23	44.98
1955	4.13	7.15	1.13	7.30	5.80	0.49	7.08	4.60	0.70	0.56	2.67	3.03	44.64
1956	2.21	8.34	6.42	2.66	3.52	2.54	1.55	2.00	0.25	3.00	3.95	7.04	43.48
1957	3.61	3.89	8.91	4.04	4.12	8.55	4.98	1.52	5.57	3.81	9.46	4.09	62.55
1958	4.62	2.83	5.16	4.85	2.62	7.27	2.21	4.64	5.21	0.68	2.60	1.52	44.21
1959	1.91	4.18	4.62	4.00	3.20	9.72	5.88	4.10	4.12	6.65	1.04	6.28	55.70
1960	4.76	3.93	5.47	1.28	2.62	2.21	1.76	7.32	0.70	4.64	1.70	3.72	40.11
1961	6.67	4.24	13.97	2.93	1.38	6.97	4.99	2.77	1.86	1.47	8.19	8.79	64.23
1962	9.31	2.44	3.25	6.12	3.85	2.85	0.62	1.70	0.67	3.27	4.34	4.98	43.40
1963	4.96	2.55	1.89	2.77	0.44	1.50	8.94	2.32	0.75	0.05	4.08	3.80	34.05
1964	5.62	2.71	7.74	11.18	5.71	2.65	4.10	2.11	3.75	2.41	12.18	3.15	63.31
1965	1.74	6.96	8.03	1.12	3.74	4.72	2.53	0.59	3.04	0.63	3.09	3.55	39.74
1966	7.25	11.13	1.99	11.02	2.16	0.89	1.84	1.98	2.53	4.44	3.44	5.70	54.37
1967	1.75	4.05	2.32	1.67	8.95	3.21	6.38	3.59	2.33	1.55	0.38	9.92	46.10
1968	6.48	2.81	3.22	6.33	5.45	1.17	4.02	4.61	1.87	0.36	5.17	8.70	50.19
1969	1.26	4.20	4.21	6.69	4.86	1.31	5.74	1.51	1.84	4.36	1.66	9.12	46.76
1970	2.41	2.24	4.56	2.64	1.71	3.45	2.95	11.11	3.98	10.44	2.58	3.95	52.02
1971	2.28	7.77	4.88	2.57	7.91	1.45	2.89	3.32	7.94	1.37	1.65	9.45	53.48
1972	6.41	2.63	7.35	0.81	3.51	2.01	5.22	2.08	3.95	4.09	3.95	11.33	53.34
1973	6.48	2.81	10.56	9.51	7.50	2.02	4.86	4.14	4.72	4.57	7.80	7.97	72.94
1974	13.18	4.00	3.22	9.06	1.43	1.66	4.32	6.52	4.13	1.24	4.65	7.92	61.33
1975	4.39	7.73	6.97	7.32	13.45	7.48	4.45	5.72	4.05	8.95	3.91	2.89	77.31
1976	6.63	3.09	14.52	0.87	6.58	2.46	4.16	0.49	4.05	3.43	2.78	4.94	52.65
1977	6.22	3.05	9.89	8.18	3.56	1.44	3.99	5.09	1.75	2.85	9.03	3.33	58.38
1978	5.86	2.82	2.84	2.15	8.39	2.25	2.77	3.49	1.99	0.60	3.44	5.08	41.68
1979	17.50	8.96	3.34	12.09	4.39	1.03	7.11	1.01	5.10	3.16	4.83	6.08	74.60
1980	6.69	3.28	12.26	7.40	6.49	3.91	2.59	0.44	3.05	5.13	3.24	0.88	55.36

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